Tharsis Rise, Mars: Is there room for a plume?

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The Tharsis Rise is an area of extensive volcanism containing the largest shield volcanoes in our solar system. A number of investigators have suggested that the sustained volcanism, geoid and topographic anomalies that comprise the Tharsis Rise to be the result of a mantle plume. Harder and Christensen (1996) presented a calculation for convection in a Mars-sized body that resulted in a single plume. However, their calculation evolved through stages of several plumes down to a single plume and took greater than the age of the solar system to develop into a single plume.

Efforts to remove the isostatic contribution to the geoid and isolate the dynamic contribution have shown that while much of the long wavelength signal can be explained by the crust, there is a significant mantle component (Kiefer et al., 1996; Whitesell and King, 2001). Furthermore, dynamic models suggesting Tharsis is largely supported by convection (Kiefer et al., 1996; Harder and Christensen, 1996; Harder, 2000; Kiefer, 2001) can justify the young ages of the Tharsis shield volcanoes. Thus, there is reason to believe that a mantle plume or plumes may exist beneath Tharsis.

Research conducted thus far has consisted of varying the Rayleigh number and rate of internal heating in an isoviscous rheology and activation energy in a temperature-dependent rheology. The geoid and topography over isoviscous plumes in a Mars-sized body are greatly reduced with increasing Rayleigh number and internal heating. Additionally, calculations over temperature-dependent plumes show that after a thick, strong lithosphere forms, the geoid and topography from a plume become even smaller. While our exploration of geoid and topography over plumes suggests that there could be a plume under Tharis, the plume hypothesis has a number of shortcomings: Why is there only one (possibly two) plume(s) on Mars?; Why has the plume remained stable over a long period of Martian history?; What heat source in the core could have produced enough heat to maintain the plume till present? Is it a coincidence that the plume is so closely spatially related to the crustal dichotomy? Because of these questions which the plume model does not adequately address, we are exploring the hypothesis that the Tharsis volcanism is due to small scale convection within the upper mantle that may behave much like edge-driven convection due to the Martian crustal dichotomy – the almost equatorial division between the heavily cratered, thick crust of the southern hemisphere and the thinner crust of the low-lying volcanic plains in the northern hemisphere.

References

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